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MR No. L5C10

ATI No. 33410

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WARTIME REPORT

ORIGINALLY ISSUED
March 1945 as
Memorandum Report L5C10

FLIGHT TESTS OF THE SIKORSKY HNS-1 (ARMY YR-4B) HELICOPTER

I - EXPERIMENTAL DATA ON LEVEL-FLIGHT PERFORMANCE

WITH ORIGINAL ROTOR BLADES

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NACA

WASHINGTON

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

MEMORANDUM REPORT

for the

Army Air Forces, Air Technical Service Command

and the

Bureau of Aeronautics, Navy Department

FLIGHT TESTS OF THE SIKORSKY HNS-1 (ARMY YR-4B) HELICOPTER

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SUMMARY

Results of performance measurements made in level flight with the HNS-1 (Army YR-4B) helicopter are presented. These data include torquemeter measurements of shaft power for both the main rotor and the tail rotor. The power data, in conjunction with full-scale-tunnel data on the lift and drag of the fuselage, are used to calculate the drag-lift ratio for the main rotor.

The following results were obtained for the HNS-1 helicopter, as tested at a gross weight of approximately 2560 pounds and equipped with the original set of main-rotor blades: minimum main-rotor-shaft power at cruising rpm, approximately 99 horsepower at a speed of 40 miles per hour; rotor-shaft power absorbed by tail rotor at cruising rpm, approximately 3 to 4 horsepower over a range of speeds from 25 to 80 miles per hour; maximum ratio of lift to drag for the main rotor attainable within the available speed range, 6.7; maximum value of weight-drag ratio (ratio of weight to the drag equivalent to the total rotor-shaft power), 3.5; speed for maximum weight-drag ratio, approximately 67 miles per hour. The results also indicate that main-rotor-shaft power required is appreciably affected by rotor rpm, a reduction in rpm of 5 percent corresponding to a reduction of approximately 3 to 4 horsepower when operating at or near the speed for minimum power.

INTRODUCTION

In order to provide data with which theory and wind-tunnel measurements on powered rotating-airfoil systems may be checked, flight tests are being conducted at Langley Laboratory with a Sikorsky HNS-1 (Army YR-4B) helicopter. These tests include performance measurements in level flight, hovering, and glides and climbs, and camera observations of blade motion in selected conditions. This report presents the results of the level-flight performance measurements that were made with the original set of main-rotor blades.

SYMBOLS

V_c calibrated airspeed (indicated airspeed corrected for instrument and installation errors; can be considered equal to $V\left(\frac{\rho}{\rho_o}\right)^{1/2}$ in the present case)

V true airspeed

ρ mass density of air

ρ_o mass density of air at sea level under standard conditions (0.002378 slug per foot^3)

θ_{av} average main rotor-blade pitch, uncorrected for play in linkage and for mean blade twist

μ tip-speed ratio $\left(\frac{V \cos \alpha}{\Omega R}\right)$

α spindle angle of an equivalent rotor with no periodic variation of the rotor-blade pitch angle, measured in the plane of symmetry and referenced to a line perpendicular to the flight path; positive aft

σ solidity $\frac{bc_e}{\pi R}$ where c_e = equivalent chord = $\dfrac{\int_0^R cr^2 dr}{\int_0^R r^2 dr}$

giving $\sigma = 0.060$ for the present case b number of blades

a slope of lift coefficient against section angle of attack (radian measure), assumed equal to 5.73 in this report

C_P power coefficient $\left(\frac{\text{Rotor-shaft power input}}{\rho\Omega^3 \pi R^5}\right)$

P/L shaft-power parameter. The symbol P is equal to the rotor-shaft power divided by the velocity along the flight path. It is, therefore, also equal to the drag force that could be overcome by the shaft power at the flight velocity

α_f fuselage angle of attack (angle between relative wind and a line in the plane of symmetry and perpendicular to the main rotor-shaft axis; positive when nose up)

$\Delta\alpha_f$ correction to fuselage angle of attack to allow for rotor downwash

α_{f_c} corrected fuselage angle of attack $(\alpha_f + \Delta\alpha_f)$

$C_{L_{uncor}}$ uncorrected rotor lift coefficient $\left(\frac{\text{Gross weight}}{\frac{1}{2}\rho V^2 \pi R^2}\right)$

ΔC_L correction to rotor lift coefficient for fuselage download

C_L rotor lift coefficient $\left(C_{L_{uncor}} + \Delta C_L\right)$

C_T thrust coefficient $\left(\frac{\text{Corrected rotor lift}}{\rho\Omega^2 \pi R^4}\right)$

$\left(\frac{D}{L}\right)_{pf}$ parasite drag of fuselage, rotor head, and blade shanks, divided by corrected main-rotor lift

$\left(\frac{D}{L}\right)_{pt}$ parasite-drag contribution of tail rotor divided by corrected main-rotor lift

$\left(\frac{D}{L}\right)_{r}$ drag-lift ratio of main rotor after applying corrections for fuselage download and for fuselage and auxiliary rotor parasite drag

C_{L_f} fuselage lift coefficient $\left(\frac{\text{Fuselage lift}}{\frac{1}{2}\rho V^2 \ \pi R^2}\right)$

C_{D_f} fuselage drag coefficient $\left(\frac{\text{Fuselage drag}}{\frac{1}{2}\rho V^2 \ \pi R^2}\right)$

R rotor-blade radius

r radius of blade element

L corrected rotor lift

Ω rotor angular velocity, radians per second

APPARATUS

Description of aircraft.- General views of the HNS-1 helicopter (AAF Serial No. 43-28229) are shown in figures 1, 2, and 3. The plan form of the main- and tail-rotor blades is shown in figure 4. Dimensions and other details for the aircraft as flown are as follows:

General characteristics:
- Gross weight as flown (±2 percent), lb 2560
- Disk loading, lb/sq ft 2.26
- Power loading as flown (normal rated power), lb/bhp 14.2
- Parasite drag area D/q, typical flight condition, sq ft 23
- Power rating for take-off . . . . 190 bhp at 2250 rpm
- Power rating, normal . . . . 180 bhp at 2100 rpm
- Gear ratio, engine to main rotor 9.34:1
- Gear ratio, engine to tail rotor 30:17
- Fuel capacity, gals 30
- Center-of-gravity position, below plane of flapping hinges, feet 4.5

Main-rotor characteristics:

Radius, ft 19
Blade twist . . . . None
Solidity, $\frac{bc_e}{\pi R}$ 0.060
Blade area (total, three blades), sq ft 65.5
Blade section . . . . NACA 0012
Mean pitch range, deg . . . . 2.5 to 14
Cyclic pitch range, obtained from:
Longitudinal stick motion, deg 16
Lateral stick motion, deg 15
Direction of rotation: counterclockwise as viewed from above
Moment of inertia of blade about flapping axis, slug ft^2 146
Blade weight (one blade), lb 53
Blade center of gravity, from ℄ of rotor shaft, in. 94.3
Drag hinge location, from ℄ of rotor shaft, in.. . 9.08
Flapping hinge ℄ location, from ℄ of rotor shaft, in. 0

Tail-rotor characteristics:

Radius, ft 3.96
Blade twist . . . . None
Solidity, $\frac{bc_e}{\pi R}$ 0.10
Blade area (total, three blades), sq ft 4.92
Blade section . . . . NACA 0012
Mean pitch range, deg . . . . -4 to 16
Shaft axis setting
Horizontal projection: rotor-shaft axis inclined 2.1° backward from perpendicular to axis of symmetry of fuselage
Vertical projection: rotor-shaft axis perpendicular to main-rotor-shaft axis.
Distance from hub center to main-rotor shaft, ft . 25.2

Instrumentation and methods.- Quantities measured during the forward-flight tests included the following:

- Airspeed
- Rotor rpm
- Engine manifold pressure
- Main-rotor-shaft torque
- Tail-rotor-shaft torque
- Free-air temperature
- Intake-air temperature
- Free-air static pressure
- Main-rotor pitch
- Tail-rotor pitch
- Attitude angle (shaft inclination)
- Upwash and yaw flow angles ahead of the rotor disk
- Cyclic pitch control position

The free-air temperature and the engine intake-air temperature were obtained from indicating instruments; all other quantities were obtained from NACA recording instruments.

The airspeed was determined by means of a double-swiveling pitot-static installation (fig. 5) having its static holes located at a point 25$\frac{3}{4}$ inches ahead of the main-rotor shaft and 5$\frac{1}{4}$ inches below the plane of the flapping hinges. The installation was calibrated by means of a trailing-pitot-static bomb suspended approximately 100 feet below the rotor. The calibration data are shown in figure 6.

The engine manifold pressure, intake-air temperature, and rpm values were used to calculate engine brake horsepower by use of the calibration curve given in Technical Order AN 01-10 DA-1.

The main- and tail-rotor-shaft torques were obtained by means of strain-gage torquometers. The strain-sensitive elements for the main rotor were mounted on the driveshaft between the gear box and the pylon thrust bearing. Those for the tail rotor were mounted on that portion of the driveshaft between the tail-rotor gear box and the rearmost shaft bearing.

The torquemeter shaft assemblies, including the strain-sensitive elements and sliprings, were designed by Baldwin-Southwark Division of the Baldwin Locomotive Works under contract with the Army Air Forces. An NACA recording galvanometer was used to measure the gage output. Voltage control and also a periodic check throughout each run on the zero reading and sensitivity of the galvanometer circuit were obtained with additional equipment developed especially for the purpose.

The values of main-rotor pitch setting and control-stick (cyclic pitch) position were obtained from control-position recorders attached to the push-pull tubes extending from inside the fuselage to the rotor head. The stick position is referred to the position for zero cyclic pitch variation. The available stick travel from this position as measured at the top of the stick is 6.0 inches forward, 7.1 inches aft, 4.1 inches right, and 7.6 inches left. The amplitude of the cyclic pitch variation, in degrees from the mean pitch value, may be estimated by multiplying the stick displacement in inches by 1.25.

The phase angle of the cyclic pitch action, in degrees from the rearmost position of the blade, may be estimated for the power-on condition by assuming that the maximum effect of the longitudinal stick deflection occurs at 65° and at 245° azimuth and that the maximum effect of the lateral stick displacement occurs at 155° and 335° azimuth. These estimates must be viewed as approximate, however, because of linkage play, periodic blade twist, and the change in the phase of the control action with changes in rotor torque or rpm.

The values for the tail-rotor pitch were obtained from a control-position recorder attached to the tail-rotor control cables. This installation was calibrated with a small pitch decreasing moment applied to the blades, to insure that the play in the system (roughly $\pm 1^{\circ}$ from the mean position) would be taken up in a direction corresponding to that anticipated for the flight conditions covered.

The attitude angle (main-rotor-shaft inclination from the vertical, positive rearward) was determined by means of a pendulum inclinometer.

The yaw and the upwash flow angles were obtained by means of a calibrated yaw head mounted on the end of the airspeed boom (fig. 4). These tubes were located 250 inches ahead of the rotor shaft and 54 inches below the plane of the flapping hinges. The angles given are referred to a line in the plane of symmetry and perpendicular to the rotor shaft. A positive yaw angle corresponds to right yaw or left sideslip.

REDUCTION OF DATA

The method of calculation of the majority of the coefficients presented will be apparent by definition. The methods of obtaining tip-speed ratio μ and rotor drag-lift ratio D/L, however, require some explanation.

<u>Tip-speed ratio μ</u>.- Evaluation of the $\cos \alpha$ term in the accepted definition of the tip-speed ratio $\mu = \dfrac{V \cos \alpha}{\Omega R}$ requires the determination of an equivalent spindle angle for a rotor with no periodic variation of the rotor-blade pitch angle. This equivalent angle was

determined by adding the amplitude of the longitudinal component of the rotor-blade cyclic pitch variation (periodic blade pitch angle change about transverse axis of ship) estimated from the stick-position data to the measured shaft angle.

Rotor drag-lift ratio D/L.- The evaluation of rotor drag-lift ratio requires a somewhat arbitrary division of the drag losses into fuselage parasite drag and rotor profile-drag losses. In this report the drag of the hub structure and the cylindrical blade shanks has been charged to fuselage parasite loss. This division is convenient because the drag of these items varies with forward speed rather than with rotational speed. It also gives a more correct index of the performance to be expected from later rotor designs, inasmuch as the relative drag of the hub structure on the HNS-1 is obviously much greater than that on any of the more recent designs.

In determining the drag-lift ratios of the main rotor from measured values of shaft power and known values of gross weight, allowances have been made for the following factors:

(1) Power required to overcome the parasite drag of the fuselage, rotor head, and blade shanks.

(2) Power required to overcome the drag force on the tail rotor. (This power is totally independent of the power transmitted through the tail rotor shaft.)

(3) Rotor lift, in excess of the gross weight, required because of the downward air load on the fuselage.

The individual values for all of these allowances have been included in table II in order that their magnitude may be noted.

Items (1) and (3) were determined by use of unpublished full-scale-tunnel data on the lift and drag of the fuselage of a YR-4B helicopter (AAF Serial No. 43-28225). These data were obtained with the airspeed boom shown in figure 5 mounted on the YR-4B fuselage, in order to make the data directly applicable to the flight tests. The measured drag coefficients were increased by 0.00035, or about 2 percent, as an allowance for the drag of the cylindrical blade shanks; this increment was estimated from data on yawed cylinders. The fuselage drag and lift curves used in the analysis are shown in figure 7. The wind-tunnel values were obtained over a range of angles of attack but the fuselage was, of course, not being subjected to the downwash from the rotor. As an approximate allowance for this downwash, the fuselage angle of attack for the flight conditions was taken as equal to the measured angle minus $57.3 (C_T/4)$ which term represents the approximate induced flow angle at the rotor.

No directly applicable data were available for evaluation of item (2). As a rational approximation, theoretical calculations similar in principle to those of the example of reference 1 were made. The process consisted in finding an airfoil-section profile-drag value which results in a calculated value of shaft power equal to the measured value. The same profile-drag value was then used to calculate the power required to pull the tail rotor. The maximum value so obtained was 3.4 horsepower; this value corresponds to maximum speed. In terms of equivalent drag area, the parasite drag allowance for the tail rotor was nearly constant, varying only from 0.8 to 1.0 square foot over the entire range of combinations of rpm and speed. The mean blade-section drag coefficient required to make the calculated tail-rotor-shaft power equal the measured shaft power varied from 0.010 to 0.015.

It will be noted that the main-rotor thrust coefficients presented are based on the assumption that rotor thrust equals rotor lift. This assumption is justified by the fact that refinement of the thrust value by inclusion of the drag component would result in a maximum difference of about 1 percent.

RESULTS

The test data corrected for instrument errors are presented in table I. The values of the main-rotor drag-lift ratio and other parameters derived from those data are given in table II.

The power-required data for the main rotor obtained from the torquemeter are plotted against true airspeed in figure 8. Because the deviations in weight and density ratio were small, no corrections have been applied for variations of these factors from their mean values in preparing the horsepower-velocity plot. A check of the error involved indicated that the maximum correction which would be applied to an individual value for horsepower, in converting to average conditions, would be less than 2 percent. In calculating dimensionless quantities, however, individual values of weight and density were employed for each test point. The data of figure 8 have been replotted in coefficient form in figure 9. The main-rotor drag-lift ratios, obtained from the power data as already described, are shown in figure 10.

The data in figures 8, 9, and 10 have been grouped according to the values of the nondimensional thrust coefficient C_T. From an operational standpoint, the thrust coefficient is most readily changed by varying the rpm of the engine and hence of the rotor, and for this reason a value of engine rpm corresponding to each value of C_T is given. For this purpose the average of the actual C_T values within each group has been used. The conversion from C_T to rpm is based on average values of weight and density and an average download allowance; as already mentioned, however, the variations in weight and density are not large enough to be significant in this connection, and examination of table II will show that the download variation is likewise small.

No data were taken at speeds below approximately 30 miles per hour because of the difficulty which the pilot experienced in maintaining steady conditions at speeds between approximately 30 miles per hour and near-hovering speeds.

DISCUSSION

Main-rotor power.- Interpolation of the data presented in figure 8 indicates a minimum value of main-rotor-shaft horsepower of approximately 99 horsepower for cruising rpm (2100 engine rpm, 225 rotor rpm) at a speed of approximately 40 miles per hour. A reduction of power required of about 3 to 4 horsepower for every 5-percent reduction in rotor rpm is also indicated over most of the speed range, including the speed for minimum power. This reduction in power required at a given speed may be attributed to the combined benefits of operating at higher pitch angles and higher tip-speed ratios while retaining fixed values of parasite and induced losses. This same trend toward lower power with lower rpm may be shown with the data in nondimensional form by plotting P/L against C_L, since the parasite and induced losses are fixed by the lift coefficient. The form of the resulting curves is believed to be more suitable for study, however, if the velocity parameter $1/\sqrt{C_L}$ is used; such a plot is shown in figure 11. The ratio $1/\sqrt{C_L}$ is approximately equal to the ratio of the actual velocity of flight to that for a lift coefficient of unity; the relation would be exact if C_L were based on weight instead of the rotor lift, which includes a varying percentage allowance for fuselage download.

Examination of figure 9 indicates that minimum P/L and hence maximum range will be obtained at a tip-speed ratio of approximately 0.22, which corresponds to a speed of 67 miles per hour at cruising rpm. The minimum value of P/L at cruising rpm, 0.265, corresponds to an equivalent lift-drag ratio of 3.8. If the lift allowance made for the fuselage download is removed and an allowance made for the power absorbed through the tail-rotor shaft, an equivalent weight-drag ratio of 3.5 is obtained for the aircraft. The values of minimum P/L for the various thrust coefficients (see faired curves of fig. 11) show relatively little effect of rotational speed; in particular, the reduction in P/L obtained by using rotational speeds below that for cruising is small. The ratios just given for the cruising condition, therefore, are considered to be reasonably representative of the performance of the aircraft as tested.

The minimum value of main rotor D/L (fig. 10) is 0.15, corresponding to an L/D of 6.7. This value was obtained from data taken with wide-open throttle. Inspection of the data of figure 10 indicates that appreciably higher rotor L/D values might be expected if higher tip-speed ratios could be reached. The extension of the tip-speed ratio values by use of lower rotational speed, however, was carried to the lowest rotational speed at which the pilot could control the aircraft. Calculations indicate that tip stalling should set in at approximately this same combination of thrust coefficient and tip-speed ratio values; consequently, further increase in tip-speed ratio and L/D would have to be obtained by an increase in forward speed rather than by reduction of rotational speed.

Tail-rotor-shaft power.- Inspection of the values of the tail-rotor power given in table I will indicate that for speeds between 25 and 80 miles per hour the tail rotor absorbs from 3 to 4 shaft horsepower at normal rpm. These data are shown plotted against velocity, with the data points grouped according to main-rotor thrust coefficient, in figure 12. Some effect of speed is evident, the tendency being a decrease in shaft power with increase in speed. There are also indications of an effect of tail-rotor rpm on shaft power; this effect is most consistently evidenced in the top-speed data (70 to 80 miles per hour, flight 9), which data indicate a reduction from about 3.5 horsepower to about 2 horsepower as the engine rpm is reduced from 2250 to 1940.

Analysis indicates that the shaft power absorbed by the tail rotor will vary with the yaw angle of the helicopter. To evaluate this effect a continuous record was taken at 70 miles per hour with the yaw angle slowly increased and decreased through a range of $\pm 15^{\circ}$. A change of one horsepower in the tail-rotor-shaft power for every 3.5° yaw was indicated, the lower shaft power corresponding to right yaw or left sideslip. Inspection of the yaw angle values given in table I in the light of this relation indicates that the maximum error in tail-rotor-shaft power, resulting from yaw of the aircraft, is approximately 0.5 horsepower.

The power absorbed by the drag of the tail rotor has already been discussed in the section entitled Reduction of Data.

CONCLUSIONS

The level-flight performance data obtained on the HNS-1 helicopter, as tested at a gross weight of approximately 2560 pounds and equipped with the original set of main-rotor blades, indicates the following conclusions.

1. The minimum shaft power required by the main rotor at cruising rpm (225 rotor rpm, 2100 engine rpm) was approximately 99 horsepower at a speed of 40 miles per hour.

2. The shaft power absorbed by the tail rotor at cruising rpm was approximately 3 to 4 horsepower over a range of speeds from 25 to 80 miles per hour.

3. A reduction of 5 percent in rotor rpm results in a reduction of approximately 3 to 4 horsepower in the value of main-rotor-shaft power, at or near the speed for minimum power.

4. The maximum lift-drag ratio for the main rotor was approximately 6.7. A higher L/D could probably be obtained if higher speeds could be reached.

5. A maximum value of weight-drag ratio (ratio of weight to the drag equivalent of the total rotor-shaft power) of 3.5 was obtained at a speed of approximately 67 miles per hour.

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REFERENCE

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TABLE I

LEVEL FLIGHT DATA SUMMARY

Flight No. 3 6/30/44

Run no.	1	2	3	4	5	6	7	8	9	10	11	12	13
Calibrated airspeed (mph)	65.6	60.6	55.0	51.8	37.3	29.3	25.2	40.4	40.8	41.3	47.4	48.6	48.7
Density ratio, ρ/ρ_0	.913	.915	.922	.918	.923	.923	.923	.923	.923	.915	.916	.919	.920
True speed (mph)	68.6	63.3	57.3	54.1	38.8	30.5	26.2	42.0	42.4	43.1	49.5	50.8	50.8
Gross weight (lbs)	2600	2597	2594	2591	2588	2585	2582	2579	2575	2572	2569	2566	2563
Rotor rpm	222	221	221	222	223	219	222	216	209	235	219	238	213
Engine rpm	2070	2060	2060	2070	2080	2050	2070	2020	1950	2190	2040	2220	1990
Atmos. pressure (in. Hg)	28.27	28.30	28.52	28.38	28.55	28.53	28.54	28.54	28.53	28.31	28.35	28.43	28.48
Free air temp. (°F)	77	77	77	77	77	77	77	77	77	77	77	77	77
Intake air temp. (°F)	—	—	—	—	—	—	—	—	—	—	—	—	—
Manifold pressure (in. Hg)	27.5	25.2	23.0	21.4	19.1	21.0	22.4	21.5	20.8	21.6	21.6	20.9	23.0
Brake hp (power charts)	163	149	135	126	112	123	132	124	116	132	126	129	131
Hp, main rotor (shaft)	130	122	110	103	89	97	102	98	92	105	103	104	109
Hp, tail rotor (shaft)	—	—	—	—	—	—	—	—	—	—	—	—	—
Pitch, main rotor (deg)	10.1	9.6	9.1	8.5	7.5	8.7	9.1	8.2	9.0	7.5	8.5	7.2	9.6
Pitch, main rotor (deg)	1.0	.3	1.4	-.1	-.5	.1	.5	.1	.6	-.5	-.1	-.8	.4
Yaw angle (deg)	-1.5	1.5	-1.1	1.2	6.1	1.8	1.0	0.4	0.9	1.3	1.5	0.7	2.7
Shaft inclination (deg)	-6.0	-5.2	-3.8	-3.7	-1.5	-.3	.1	-1.8	-2.0	-2.1	-3.3	-3.6	-3.7
c.g. (in. behind shaft)	-.6	-.6	-.6	-.7	-.7	-.7	-.8	-.8	-.8	-.9	-.9	-.9	-.9
Upwash at A.S. head (deg)	-5.6	-5.0	-3.8	-2.4	1.8	3.7	2.9	-1.2	0.0	-2.5	-2.8	-2.1	-4.3
Stick position (in. fwd.)	2.1	1.8	1.9	1.4	1.3	1.5	1.3	1.6	1.7	1.3	1.4	1.1	1.7
Stick position (in. left)	4.3	4.3	3.4	3.4	2.7	3.2	3.5	3.2	3.6	3.0	3.3	2.8	3.2

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TABLE I (cont.)

LEVEL FLIGHT DATA SUMMARY

Flight No. 4 7/5/44

Run no.	1	2	3	4	5	6	7	8	9	10	11	12	13
Calibrated airspeed (mph)	55.8	54.7	55.8	45.1	46.6	45.0	46.3	36.7	35.9	38.0	36.6	36.6	41.5
Density ratio, ρ/ρ_0	.925	.925	.924	.927	.931	.930	.923	.920	.922	.920	.920	.920	.919
True speed (mph)	58.0	56.9	58.1	46.8	48.3	46.7	48.2	38.3	37.4	39.6	38.2	38.2	43.3
Gross weight (lbs)	2593	2590	2587	2585	2582	2579	2576	2574	2571	2568	2565	2563	2560
Rotor rpm	238	222	210	237	223	210	207	239	222	211	213	205	222
Engine rpm	2220	2070	1960	2210	2080	1960	1930	2230	2070	1970	1990	1910	2070
Atmos. pressure (in. Hg)	28.26	28.23	28.20	28.34	28.41	28.33	28.33	28.24	28.29	28.26	28.26	28.19	28.15
Free air temp. (°F)	70	69	69	70	69	69	72	72	72	72	72	72	72
Intake air temp. (°F)	--	--	--	--	--	--	--	--	--	--	--	--	--
Manifold pressure (in. Hg)	22.7	20.3	22.7	20.9	21.0	20.5	20.5	20.4	20.3	20.4	20.9	20.7	20.1
Brake hp (power charts)	142	120	129	129	125	116	114	127	119	115	119	114	118
Hp, main rotor (shaft)	122	101	109	110	104	96	94	105	99	94	99	93	96
Hp, tail rotor (shaft)	3.1	2.9	2.3	3.1	2.9	2.7	2.7	3.7	3.4	3.2	3.3	3.1	3.4
Pitch, main rotor (deg)	8.1	8.4	9.9	7.6	8.4	9.1	9.3	7.4	8.1	8.8	8.9	9.3	8.3
Pitch, tail rotor (deg)	0.0	0.0	0.1	-0.3	0.7	0.6	1.0	0.1	1.0	1.5	1.3	1.7	0.3
Yaw angle (deg)	-1.1	0.5	-0.2	0.3	0.0	-0.9	-0.9	-0.6	0.5	-0.6	-2.2	-3.2	-1.1
Shaft inclination (deg)	-4.5	-4.1	-4.1	-2.7	-2.7	-2.7	-2.8	-1.7	-1.8	-1.7	-1.7	-1.7	-2.3
c.g. (in. behind shaft)	-.6	-.7	-.7	-.7	-.8	-.8	-.8	-.9	-.9	-.9	-.9	-1.0	-1.0
Upwash at A.S. head (deg)	-4.0	-1.5	-3.7	-1.8	-1.4	-.7	-.8	1.0	1.3	.7	1.0	1.0	0.0
Stick position (in. fwd.)	1.3	1.7	1.7	1.3	1.4	1.8	1.9	1.2	1.3	1.5	1.5	1.5	1.3
Stick position (in. left)	3.0	3.4	4.0	2.9	3.2	3.5	3.8	2.7	3.2	3.5	3.4	3.5	3.0

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

TABLE I (cont.)

LEVEL FLIGHT DATA SUMMARY

Flight No. 4 (cont.) 7/5/44

Run no.	14	15	16	17	18
Calibrated airspeed (mph)	50.1	31.2	31.1	31.2	31.1
Density ratio, ρ/ρ_o	.919	.920	.921	.914	.911
True speed (mph)	52.2	32.5	32.4	32.6	32.6
Gross weight (lbs)	2557	2555	2552	2549	2546
Rotor rpm	223	221	237	211	207
Engine rpm	2080	2070	2210	1970	1930
Atmos. pressure (in. Hg)	28.15	28.20	28.25	28.05	27.93
Free air temp. (^oF)	72	72	72	72	72
Intake air temp. (^oF)	--	--	--	--	--
Manifold pressure (in. Hg)	20.4	20.5	20.6	22.0	20.7
Brake hp (power charts)	121	120	127	125	115
Hp, main rotor (shaft)	100	100	104	102	94
Hp, tail rotor (shaft)	3.4	3.4	4.2	3.7	3.6
Pitch, main rotor (deg)	8.4	8.1	7.5	9.3	9.3
Pitch, tail rotor (deg)	.1	1.9	.7	1.5	1.5
Yaw angle (deg)	-1.2	-2.6	-0.9	0.0	-0.9
Shaft inclination (deg)	-3.8	-0.9	-1.0	-1.0	-1.0
c.g. (in. behind shaft)	-1.0	-1.1	-1.1	-1.1	-1.2
Upwash at A.S. head (deg)	-1.4	3.0	1.9	0.7	3.0
Stick position (in. fwd.)	1.3	1.3	1.2	1.4	1.4
Stick position (in. left)	3.0	2.9	2.7	3.5	3.7

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

TABLE I (cont.)

LEVEL FLIGHT DATA SUMMARY

Flight No. 5 7/25/44

Run no.	1	2	3	4	5	6	8	9	10
Calibrated airspeed (mph)	71.5	60.4	49.2	42.0	32.2	33.6	36.4	51.4	65.1
Density ratio, ρ/ρ_0	.915	.915	.915	.916	.916	.919	.918	.918	.916
True speed (mph)	74.7	63.1	51.4	43.9	33.6	35.0	38.0	53.6	68.0
Gross weight (lbs)	2539	2533	2533	2527	2521	2521	2515	2515	2512
Rotor rpm	227	225	225	225	224	226	223	225	223
Engine rpm	2120	2100	2100	2100	2090	2110	2090	2100	2090
Atmos. pressure (in. Hg)	28.71	28.66	28.71	28.72	28.65	28.77	28.80	28.80	28.77
Free air temp. (°F)	84	84	84	83.6	83.0	83.6	84.6	84.6	84.6
Intake air temp. (°F)	—	—	—	—	—	—	—	—	—
Manifold pressure (in. Hg)	27.8	23.7	20.4	20.4	21.4	20.7	21.2	22.6	25.8
Brake hp (power charts)	169	140	121	120	126	123	124	134	154
Hp, main rotor (shaft)	146	120	99	97	105	100	103	113	130
Hp, tail rotor (shaft)	2.5	4.0	4.1	4.2	4.3	4.3	4.7	4.0	3.3
Pitch, main rotor (deg)	10.3	9.1	8.2	8.1	8.2	7.9	8.2	8.7	9.6
Pitch, tail rotor (deg)	.7	.6	.1	.6	1.4	1.2	.8	.4	.4
Yaw angle (deg)	.3	-.4	.3	-.9	-.8	0.0	0.6	0.0	0.0
Shaft inclination (deg)	-6.5	-5.2	-3.3	-2.4	-1.1	-1.0	-1.7	-4.1	-6.5
c.g. (in. behind shaft)	-.6	-.6	-.6	-.7	-.8	-.8	-.8	-.8	-.8
Upwash at A.S. head (deg)	-5.8	-4.0	-.9	-1.5	-1.4	0.0	-2.0	-4.0	-5.5
Stick position (in. fwd.)	1.9	1.8	1.5	1.4	1.4	1.3	1.3	1.5	1.7
Stick position (in. left)	4.3	3.5	3.0	2.9	2.9	2.9	3.0	3.2	3.9

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

TABLE I (cont.)

LEVEL FLIGHT DATA SUMMARY

Flight No. 9 9/16/44

Run no.	1	2	3	4	5	6	7	8	9	10	11	12	13
Calibrated airspeed (mph)	74.8	74.4	71.4	72.1	70.5	71.0	70.1	71.7	72.8	71.4	75.2	74.0	74.0
Density ratio, ρ/ρ_0	.943	.935	.932	.932	.930	.930	.926	.925	.924	.925	.930	.929	.930
True speed (mph)	77.0	76.9	74.0	74.7	73.1	73.6	73.0	74.5	75.8	74.2	78.0	76.8	76.8
Gross weight (lbs)	2583	2580	2577	2571	2571	2565	2562	2556	2553	2552	2550	2550	2547
Rotor rpm	242	240	206	205	204	211	212	219	217	218	227	228	229
Engine rpm	2260	2240	1920	1910	1900	1970	1970	2050	2030	2030	2110	2130	2130
Atmos. pressure (in. Hg)	29.03	28.85	28.91	28.91	28.85	28.93	28.83	28.80	28.75	28.71	28.83	28.81	28.86
Free air temp. (^oF)	74	76	78	78	78	80	80	80	80	79	78	78	78
Intake air temp. (^oF)	90	90	86	90	90	93	90	92	92	92	100	95	100
Manifold pressure (in. Hg)	27.9	27.8	28.2	28.2	28.0	28.0	28.0	28.0	27.9	27.9	27.9	27.9	27.9
Brake hp (power charts)	180	177	159	158	155	160	161	166	165	164	168	170	169
Hp, main rotor (shaft)	154	153	134	134	134	137	137	142	140	140	144	146	147
Hp, tail rotor (shaft)	4.0	3.5	2.0	2.4	1.7	2.7	2.1	2.7	2.6	2.6	2.9	3.3	2.9
Pitch, main rotor (deg)	9.6	9.7	12.2	12.2	12.2	11.7	11.7	11.2	11.2	11.2	10.6	10.6	10.6
Pitch, tail rotor (deg)	0.8	0.1	1.5	2.3	1.7	1.5	1.1	1.1	1.0	1.2	0.7	1.0	0.8
Yaw angle (deg)	-2.9	-0.7	-0.5	-1.5	-1.7	-1.2	-0.6	-0.9	-1.4	-1.7	-0.8	-1.3	-1.4
Shaft inclination (deg)	-8.3	-8.5	-7.8	-7.8	-7.6	-7.6	-7.8	-8.3	-8.6	-8.4	-9.2	-9.2	-9.2
c.g. (in. behind shaft)	-1.6	-1.6	-1.7	-1.7	-1.7	-1.8	-1.8	-1.9	-1.9	-1.9	-1.9	-1.9	-2.0
Upwash at A.S. head (deg)	-7.2	-7.2	-6.8	-5.7	-5.7	-6.3	-6.8	-7.5	-7.4	-7.5	-7.7	-8.2	-8.2
Stick position (in. fwd.)	1.2	0.9	2.0	2.3	2.6	2.2	1.7	1.4	1.8	1.8	1.2	1.1	1.1
Stick position (in. left)	3.9	4.0	5.7	5.8	6.2	6.2	5.4	4.9	5.0	4.9	4.6	4.5	4.5

TABLE I (cont.)

LEVEL FLIGHT DATA SUMMARY

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

Flight No. 9 (cont.) 9/16/44

Run no.	14	15	16	17	18	19	20	21	22	23	24	25
Calibrated airspeed (mph)	76.3	76.0	72.8	69.0	69.3	68.6	68.3	62.8	66.0	67.0	66.0	67.0
Density ratio, ρ/ρ_0	.936	.931	.931	.932	.932	.933	.935	.940	.935	.937	.936	.935
True speed (mph)	78.9	78.8	75.4	71.5	71.8	71.0	70.6	64.7	68.2	69.2	68.2	69.3
Gross weight (lbs)	2538	2538	2535	2529	2526	2523	2523	2520	2517	2517	2514	2511
Rotor rpm	234	237	225	220	215	228	229	227	228	229	222	218
Engine rpm	2180	2200	2100	2060	2000	2130	2140	2110	2130	2140	2070	2040
Atmos. pressure (in. Hg)	28.92	28.90	28.87	29.05	29.05	28.89	28.94	29.03	28.88	28.94	28.96	28.88
Free air temp. (°F)	76	78	78	78	78	77	77	76	76	76	77	76
Intake air temp. (°F)	110	110	110	105	105	100	100	100	100	96	92	98
Manifold pressure (in. Hg)	27.9	27.9	28.0	26.1	26.1	24.7	24.7	23.0	22.9	22.9	24.8	24.7
Brake hp (power charts)	170	174	165	152	149	150	150	139	138	141	147	145
Hp, main rotor (shaft)	148	151	145	133	130	129	129	117	118	118	126	123
Hp, tail rotor (shaft)	3.4	3.4	3.2	2.7	2.7	3.3	3.6	3.3	3.7	3.9	3.2	3.1
Pitch, main rotor (deg)	10.1	10.1	10.7	10.6	10.6	9.6	9.6	9.1	9.0	9.0	10.2	10.1
Pitch, tail rotor (deg)	0.5	0.8	0.8	1.2	0.8	0.4	0.3	0.2	0.8	0.0	0.8	1.2
Yaw angle (deg)	-1.0	-1.2	-0.4	-1.6	-1.1	-0.3	-0.1	-0.5	-2.1	-0.9	-0.6	-2.1
Shaft inclination (deg)	-9.5	-9.6	-9.3	-8.0	-8.2	-8.1	-8.1	-6.8	-7.8	-7.8	-7.9	-8.1
c.g. (in. behind shaft)	-2.1	-2.1	-2.1	-2.2	-2.2	-2.2	-2.2	-2.3	-2.3	-2.3	-2.3	-2.4
Upwash at A.S. head (deg)	-8.6	-8.4	-8.0	-7.5	-7.5	-7.0	-7.6	-5.4	-6.6	-5.6	-7.8	-7.2
Stick position (in. fwd.)	0.9	1.0	0.9	1.2	1.2	0.8	0.7	0.8	0.7	0.8	0.8	0.8
Stick position (in. left)	4.2	4.1	4.5	4.5	4.5	3.8	3.7	3.5	3.4	3.5	4.1	4.0

L-595

TABLE II

ROTOR DRAG-LIFT RATIOS AND RELATED PARAMETERS

DERIVED FROM LEVEL-FLIGHT DATA

Flight	Run	V_c (mph)	V (mph)	θ_M	μ	$(C_L)_{uncor}$	$\Delta\alpha_r$	α_{r_c}	ΔC_L	C_L	$\frac{C_L}{\sigma}$	C_T	$\frac{2C_T}{\sigma a}$	$C_p \times 10^3$	$\frac{C_P}{C_T}$	$\frac{P}{L}$	$\left(\frac{D}{L}\right)_{pf}$	$\left(\frac{D}{L}\right)_{pt}$	$\left(\frac{D}{L}\right)_r$
3	1	65.6	68.6	10.1	0.224	0.216	-3.1	-9.1	0.005	0.221	3.66	0.0055	0.0322	0.339	0.0614	0.267	0.086	0.004	0.177
	2	60.6	63.3	9.6	.208	.251	-3.6	-8.8	.004	.256	4.26	.0055	.0321	.320	.0580	.272	.073	.003	.196
	3	55.0	57.3	9.1	.190	.294	-4.2	-8.0	.004	.298	4.97	.0054	.0316	.285	.0524	.274	.062	.003	.209
	4	51.8	54.1	8.5	.179	.335	-4.8	-8.5	.004	.339	5.66	.0054	.0316	.267	.0492	.273	.055	.002	.216
	5	37.3	38.8	7.5	.127	.655	-9.4	-10.9	.006	.660	11.00	.0053	.0308	.226	.0426	.330	.030	.002	.299
	6	29.3	30.5	8.7	.102	1.043	-14.9	-15.2	.008	1.051	17.52	.0055	.0318	.258	.0472	.458	.020	.002	.436
	7	25.2	26.2	9.1	.087	1.399	-20.0	-19.9	.012	1.411	23.51	.0054	.0311	.263	.0491	.560	.016	.002	.542
	8	40.4	42.0	8.2	.142	.551	-7.9	-9.7	.005	.556	9.27	.0056	.0327	.271	.0482	.336	.035	.002	.299
	9	40.8	42.4	9.0	.149	.538	-7.7	-9.7	.005	.543	9.06	.0060	.0351	.284	.0471	.313	.035	.002	.275
	10	41.3	43.1	7.5	.135	.521	-7.5	-9.6	.005	.526	8.77	.0048	.0278	.229	.0478	.352	.037	.002	.313
	11	47.4	49.5	8.5	.164	.407	-5.8	-9.1	.005	.412	6.85	.0055	.0321	.278	.0503	.301	.046	.002	.253
	12	48.6	50.8	7.2	.156	.378	-5.4	-9.0	.004	.382	6.38	.0046	.0270	.217	.0468	.295	.049	.002	.243
	13	48.7	50.8	9.6	.175	.374	-5.4	-9.1	.005	.379	6.31	.0058	.0337	.318	.0548	.310	.050	.002	.258
4	1	55.8	58.0	8.1	.178	.290	-4.2	-8.6	.004	.294	4.91	.0047	.0272	.252	.0540	.299	.063	.003	.233
	2	54.7	56.9	8.4	.188	.302	-4.3	-8.4	-.004	.306	5.10	.0054	.0314	.260	.0482	.252	.061	.003	.198
	3	55.8	58.1	9.9	.201	.286	-4.1	-8.3	.004	.290	4.83	.0060	.0349	.330	.0550	.268	.059	.003	.207
	4	45.1	46.8	7.6	.144	.447	-6.4	-9.1	.005	.452	7.52	.0047	.0272	.230	.0492	.338	.042	.002	.294
	5	46.6	48.3	8.4	.157	.425	-6.1	-8.8	.004	.430	7.15	.0053	.0307	.263	.0500	.309	.044	.002	.263
	6	45.0	46.7	9.1	.162	.448	-6.4	-9.1	.005	.453	7.53	.0059	.0344	.288	.0486	.296	.042	.002	.252
	7	46.3	48.2	9.3	.168	.430	-6.2	-9.0	.004	.434	7.24	.0061	.0356	.297	.0484	.281	.044	.002	.235
	8	36.7	38.3	7.4	.118	.658	-9.4	-11.1	.006	.664	11.07	.0046	.0268	.217	.0471	.396	.030	.002	.365
	9	35.9	37.4	8.1	.123	.701	-10.0	-11.8	.006	.706	11.77	.0053	.0310	.255	.0478	.383	.029	.002	.353
	10	38.0	39.6	8.8	.137	.619	-8.9	-10.6	.005	.624	10.40	.0059	.0341	.280	.0477	.343	.031	.002	.309
	11	36.6	38.2	8.9	.131	.667	-9.5	-11.2	.006	.672	11.20	.0058	.0336	.288	.0498	.375	.030	.002	.344
	12	36.6	38.2	9.3	.136	.669	-9.6	-11.3	.006	.674	11.24	.0062	.0363	.304	.0487	.353	.030	.002	.322
	13	41.5	43.3	8.3	.143	.519	-7.4	-9.7	.005	.524	8.73	.0053	.0311	.249	.0466	.321	.037	.002	.282
	14	50.1	52.2	8.4	.170	.363	-5.2	-9.0	.004	.368	6.11	.0053	.0309	.256	.0483	.278	.051	.002	.224
	15	31.2	32.5	8.1	.108	.904	-12.9	-13.8	.007	.911	15.19	.0053	.0310	.260	.0488	.448	.022	.002	.424
	16	31.1	32.4	7.5	.100	.919	-13.2	-14.2	.008	.926	15.44	.0046	.0269	.219	.0472	.468	.022	.002	.444
	17	31.2	32.6	9.3	.113	.911	-13.0	-14.0	.008	.918	15.30	.0059	.0342	.306	.0520	.456	.022	.002	.432
	18	31.1	32.6	9.3	.115	.920	-13.2	-14.2	.008	.928	15.46	.0061	.0356	.301	.0492	.422	.022	.002	.398

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

L-595

TABLE II - Continued

ROTOR DRAG-LIFT RATIOS AND RELATED PARAMETERS

DERIVED FROM LEVEL-FLIGHT DATA

Flight	Run	V_c (mph)	V (mph)	θ_M	μ	$(C_L)_{uncor}$	$\Delta\alpha_r$	α_{r_c}	ΔC_L	C_L	$\frac{C_L}{\sigma}$	C_T	$\frac{2C_T}{\sigma a}$	$C_P \times 10^3$	$\frac{C_P}{C_T}$	$\frac{P}{L}$	$\left(\frac{D}{L}\right)_{pf}$	$\left(\frac{D}{L}\right)_{pt}$	$\left(\frac{D}{L}\right)_r$
5	1	71.5	74.7	10.3	0.238	0.177	-2.5	-9.0	0.004	0.182	3.02	0.0051	0.0298	0.352	0.0685	0.281	0.104	0.004	0.173
	2	60.4	63.1	9.1	.204	.245	-3.5	-8.7	.004	.250	4.15	.0052	.0302	.298	.0574	.277	.075	.003	.199
	3	49.2	51.4	8.2	.166	.361	-5.2	-8.5	.004	.365	6.07	.0052	.0300	.246	.0477	.282	.055	.002	.224
	4	42.0	43.9	8.1	.142	.503	-7.2	-9.6	.005	.508	8.47	.0051	.0299	.241	.0470	.325	.038	.002	.285
	5	32.2	33.6	8.2	.108	.873	-12.5	-13.6	.007	.880	14.67	.0052	.0299	.263	.0511	.461	.022	.002	.437
	6	33.6	35.0	7.9	.114	.770	-11.0	-12.0	.006	.776	12.75	.0050	.0294	.244	.0483	.422	.022	.002	.398
	8	36.4	38.0	8.2	.124	.667	-9.6	-11.2	.006	.673	11.20	.0052	.0300	.262	.0507	.400	.030	.002	.370
	9	51.4	53.6	8.7	.173	.338	-4.8	-8.9	.004	.342	5.70	.0051	.0298	.280	.0547	.310	.055	.002	.253
	10	65.1	68.0	9.6	.220	.212	-3.0	-9.5	.005	.217	3.62	.0053	.0306	.331	.0629	.279	.088	.004	.187
9	1	74.8	77.0	9.6	.230	.165	-2.4	-10.7	.005	.170	2.84	.0045	.0262	.298	.0662	.281	.114	.004	.163
	2	74.4	76.9	9.7	.231	.167	-2.4	-10.9	.006	.173	2.88	.0046	.0269	.307	.0664	.280	.113	.004	.163
	3	71.4	74.0	12.2	.258	.183	-2.6	-10.4	.005	.188	3.14	.0063	.0365	.428	.0682	.256	.102	.005	.149
	4	72.1	74.7	12.2	.260	.181	-2.6	-10.4	.005	.186	3.10	.0063	.0366	.431	.0685	.254	.103	.005	.146
	5	70.5	73.1	12.2	.254	.192	-2.8	-10.4	.005	.197	3.29	.0064	.0370	.440	.0692	.260	.098	.005	.158
	6	71.0	73.6	11.7	.247	.190	-2.7	-10.3	.005	.195	3.26	.0060	.0346	.408	.0684	.265	.099	.004	.162
	7	70.1	73.0	11.7	.246	.191	-2.7	-10.5	.005	.196	3.27	.0059	.0345	.405	.0683	.267	.099	.004	.164
	8	71.7	74.5	11.2	.242	.183	-2.6	-10.9	.006	.188	3.13	.0055	.0320	.376	.0682	.272	.103	.004	.164
	9	72.8	75.8	11.2	.248	.177	-2.5	-11.1	.006	.183	3.05	.0056	.0327	.382	.0680	.262	.107	.005	.150
	10	71.4	74.2	11.2	.243	.184	-2.6	-11.0	.006	.190	3.16	.0056	.0325	.381	.0682	.269	.103	.005	.162
	11	75.2	78.0	10.6	.245	.166	-2.4	-11.6	.006	.172	2.87	.0052	.0300	.345	.0667	.262	.114	.005	.143
	12	74.0	76.8	10.6	.240	.171	-2.4	-11.6	.006	.177	2.95	.0051	.0296	.343	.0674	.270	.111	.005	.154
	13	74.0	76.8	10.6	.240	.170	-2.4	-11.6	.006	.176	2.93	.0051	.0294	.343	.0678	.272	.112	.005	.156
	14	76.3	78.9	10.1	.241	.160	-2.3	-11.8	.006	.166	2.76	.0048	.0280	.322	.0668	.267	.119	.005	.143
	15	76.0	78.8	10.1	.237	.161	-2.3	-11.9	.006	.167	2.78	.0047	.0273	.315	.0670	.273	.118	.004	.150
	16	72.8	75.4	10.7	.238	.178	-2.6	-11.8	.006	.184	3.06	.0052	.0303	.355	.0681	.274	.107	.004	.162
	17	69.0	71.5	10.6	.233	.192	-2.8	-10.8	.006	.198	3.31	.0054	.0314	.347	.0644	.268	.098	.004	.166
	18	69.3	71.8	10.6	.241	.189	-2.7	-10.9	.006	.195	3.24	.0057	.0330	.366	.0647	.261	.100	.004	.157
	19	68.6	71.0	9.6	.223	.195	-2.8	-10.9	.006	.201	3.34	.0050	.0290	.302	.0605	.262	.097	.004	.161
	20	68.3	70.6	9.6	.222	.194	-2.8	-10.9	.006	.200	3.32	.0049	.0286	.296	.0602	.264	.098	.004	.163
	21	62.8	64.7	9.1	.208	.225	-3.2	-10.0	.005	.230	3.85	.0050	.0290	.277	.0555	.263	.084	.003	.176
	22	66.0	68.2	9.0	.215	.209	-3.0	-10.8	.006	.214	3.57	.0050	.0288	.276	.0556	.251	.091	.003	.157
	23	67.0	69.2	9.0	.217	.202	-2.9	-10.7	.005	.207	3.47	.0049	.0284	.271	.0553	.247	.094	.004	.150
	24	66.0	68.2	10.2	.220	.210	-3.0	-10.9	.006	.216	3.59	.0052	.0304	.318	.0609	.269	.091	.004	.175
	25	67.0	69.3	10.1	.228	.202	-2.9	-11.0	.006	.208	3.45	.0054	.0313	.327	.0606	.258	.094	.004	.160

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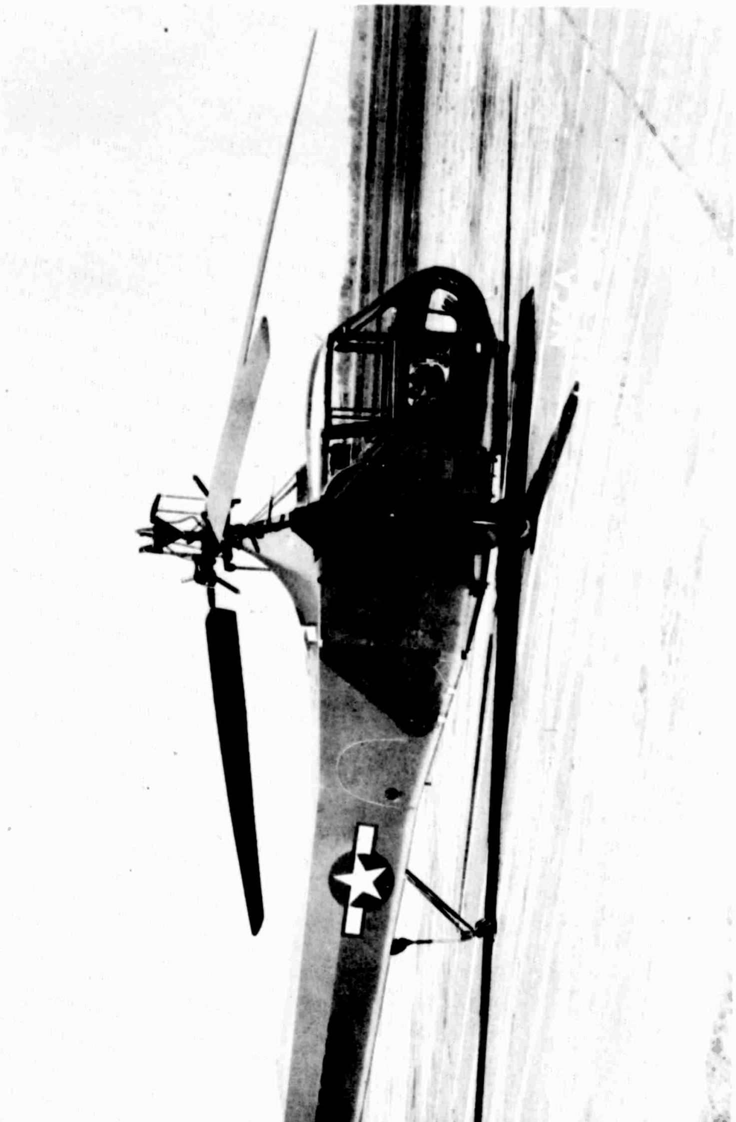

Figure 1.- HNS-1 helicopter, side view.

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Figure 2.- HNS-1 helicopter, front three-quarter view.

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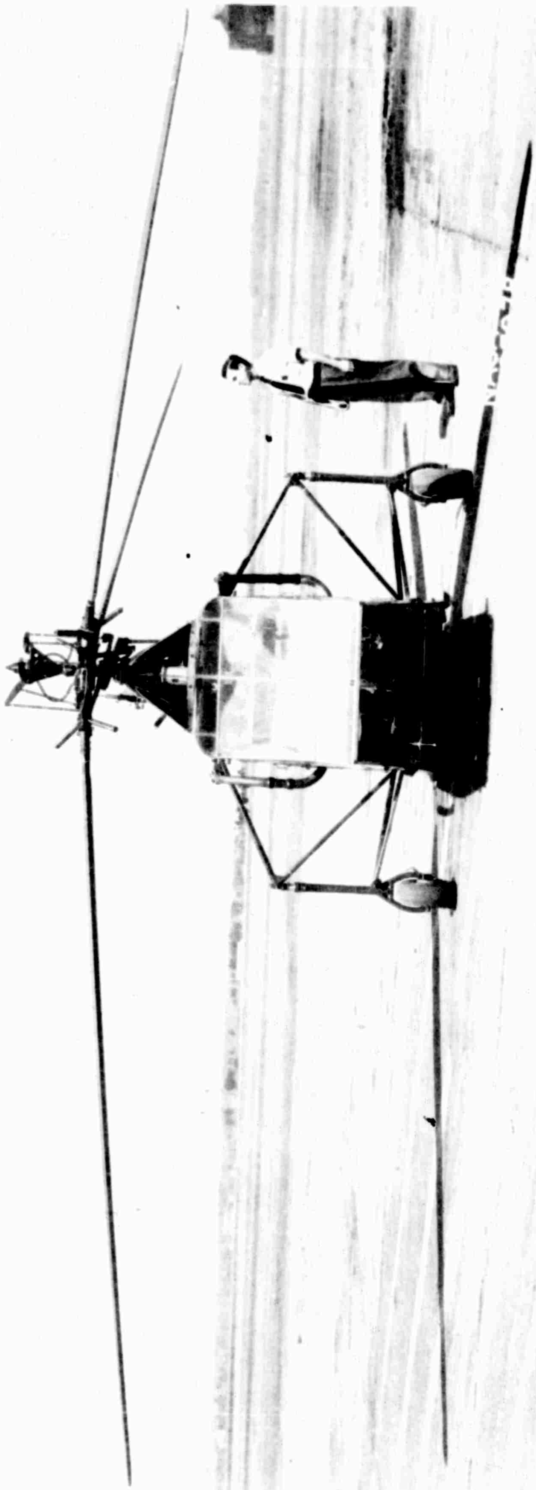
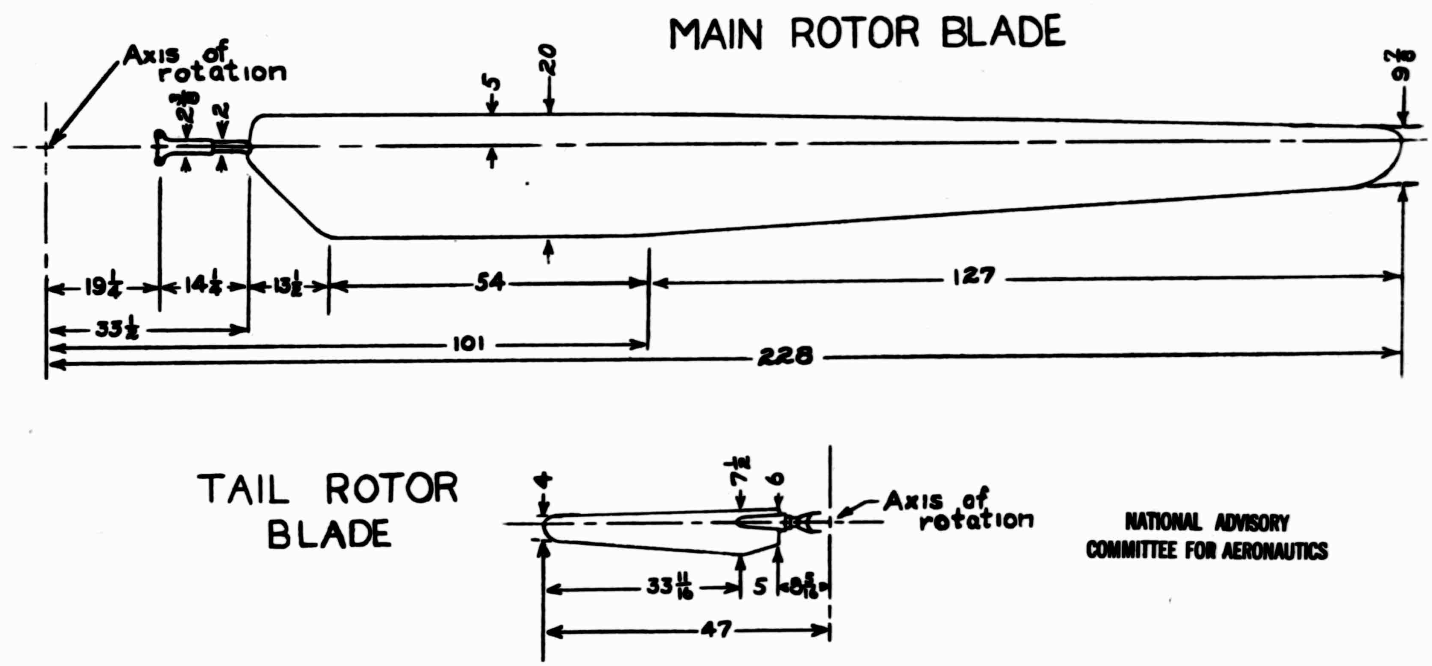


Figure 3.- HNS-1 helicopter, front view.



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All dimensions given
in inches
scale : 1" = 24"

Figure 4.- Planform dimensions of YR-4B main- and tail-rotor blades.

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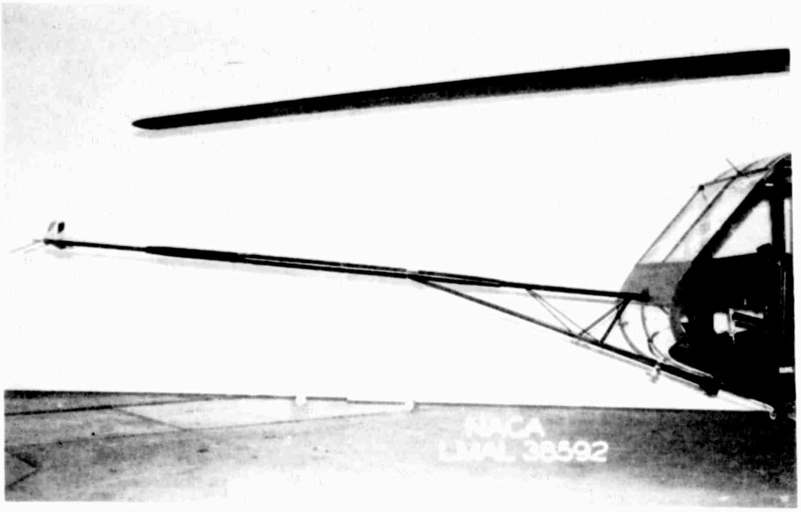

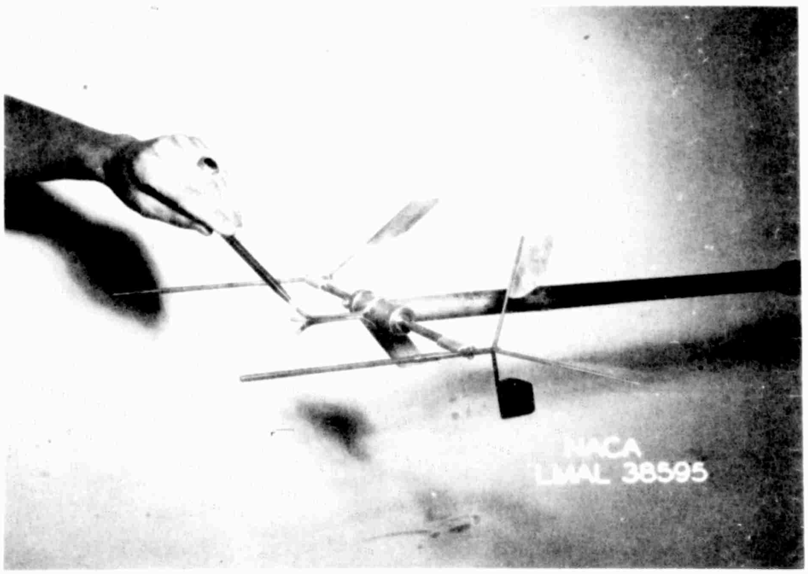

Figure 5.- Airspeed boom and details of pitot-static and flow-angle pressure-tube installations.

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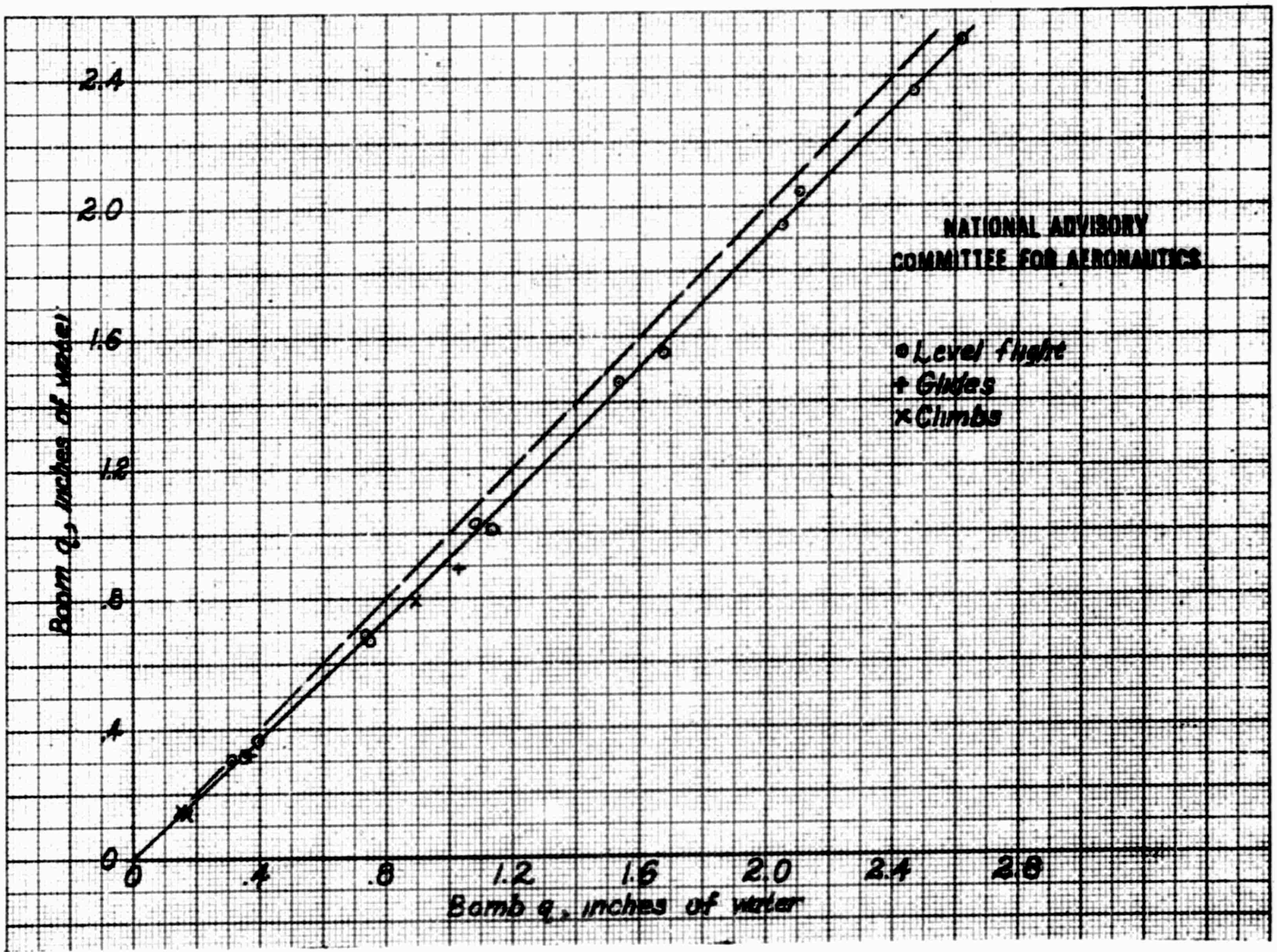

Figure 6.- Calibration of airspeed installation.

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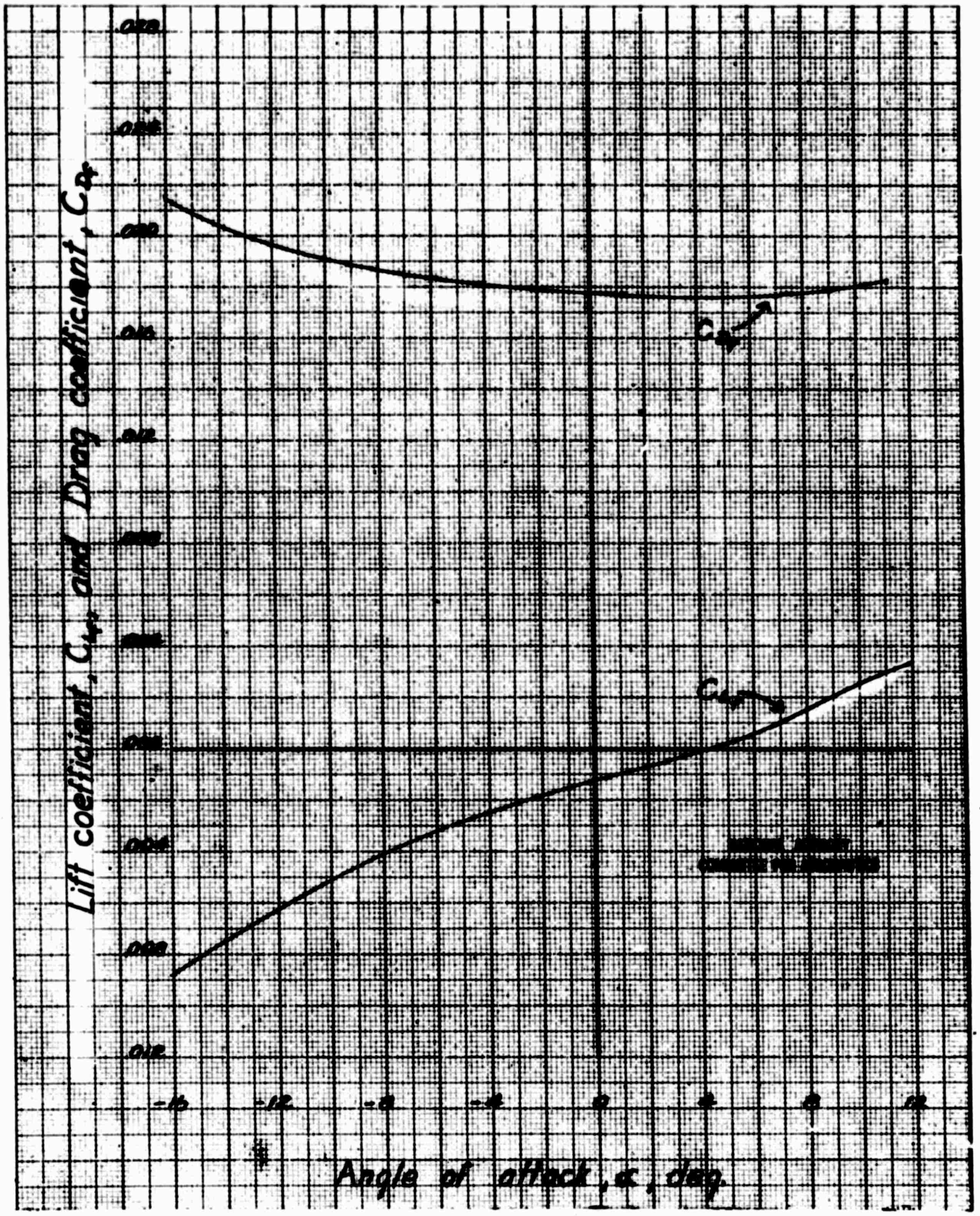

Figure 7.- Fuselage drag and lift curves as used in reduction of data; HNS-1 helicopter.

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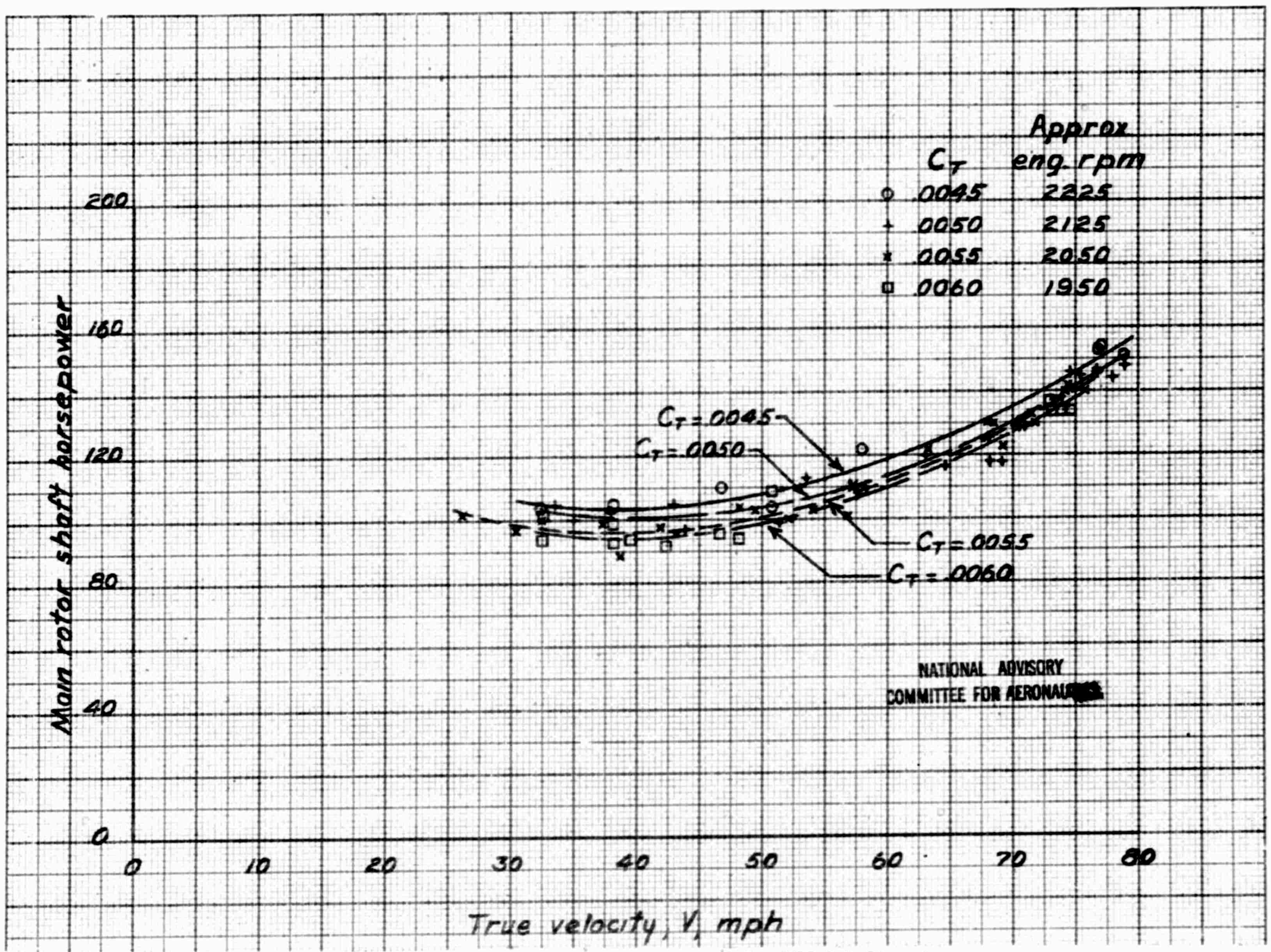

Figure 8.- Main rotor shaft power vs. true speed for HNS-1 helicopter in level flight. Gross weight as flown, 2560 pounds ±2 percent; density ratio ρ/ρ_0, .924 ±1.5 percent.

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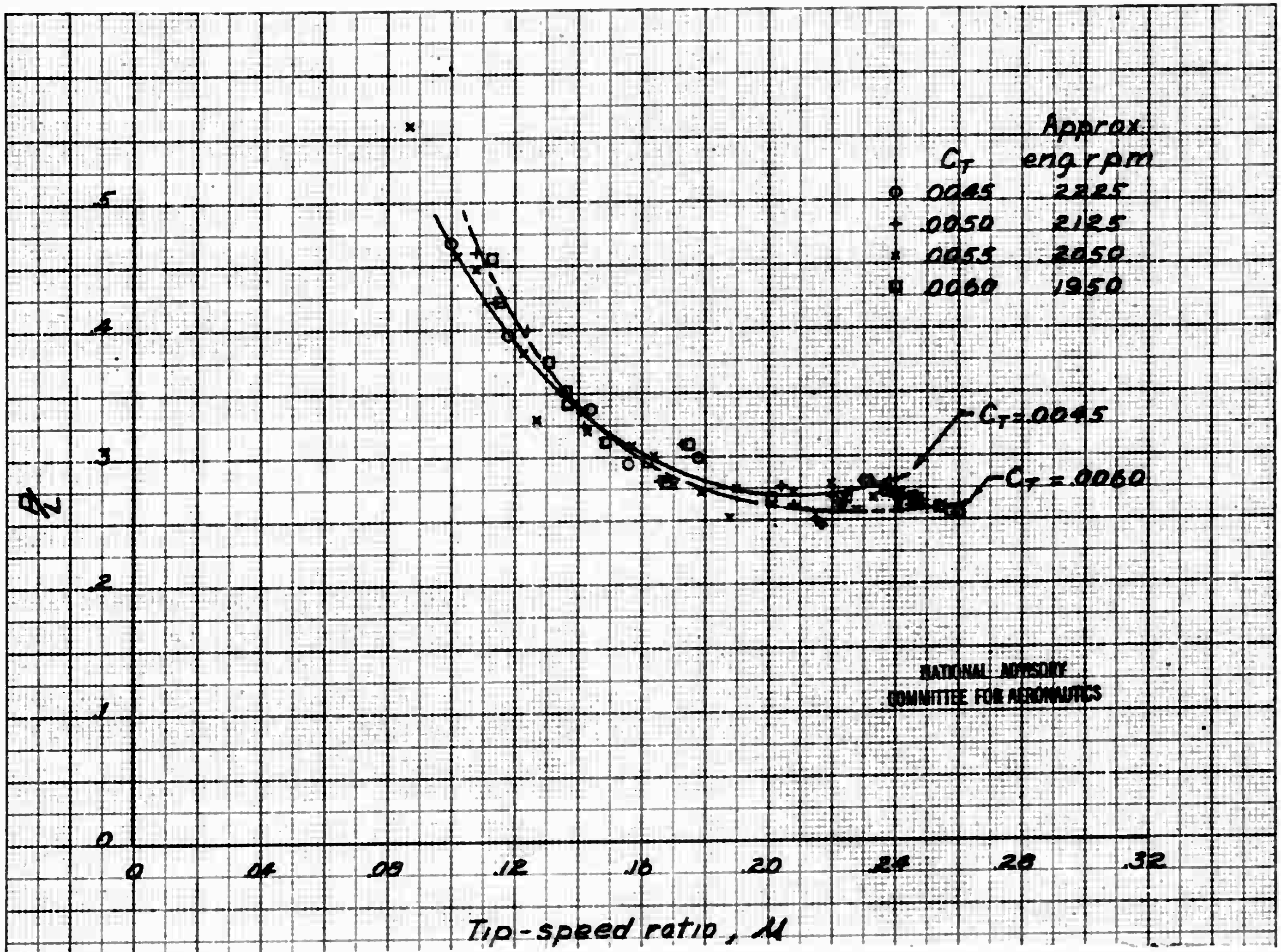

Figure 9.- Ratio of equivalent drag P to lift L for the main rotor; HNS-1 helicopter in horizontal flight.

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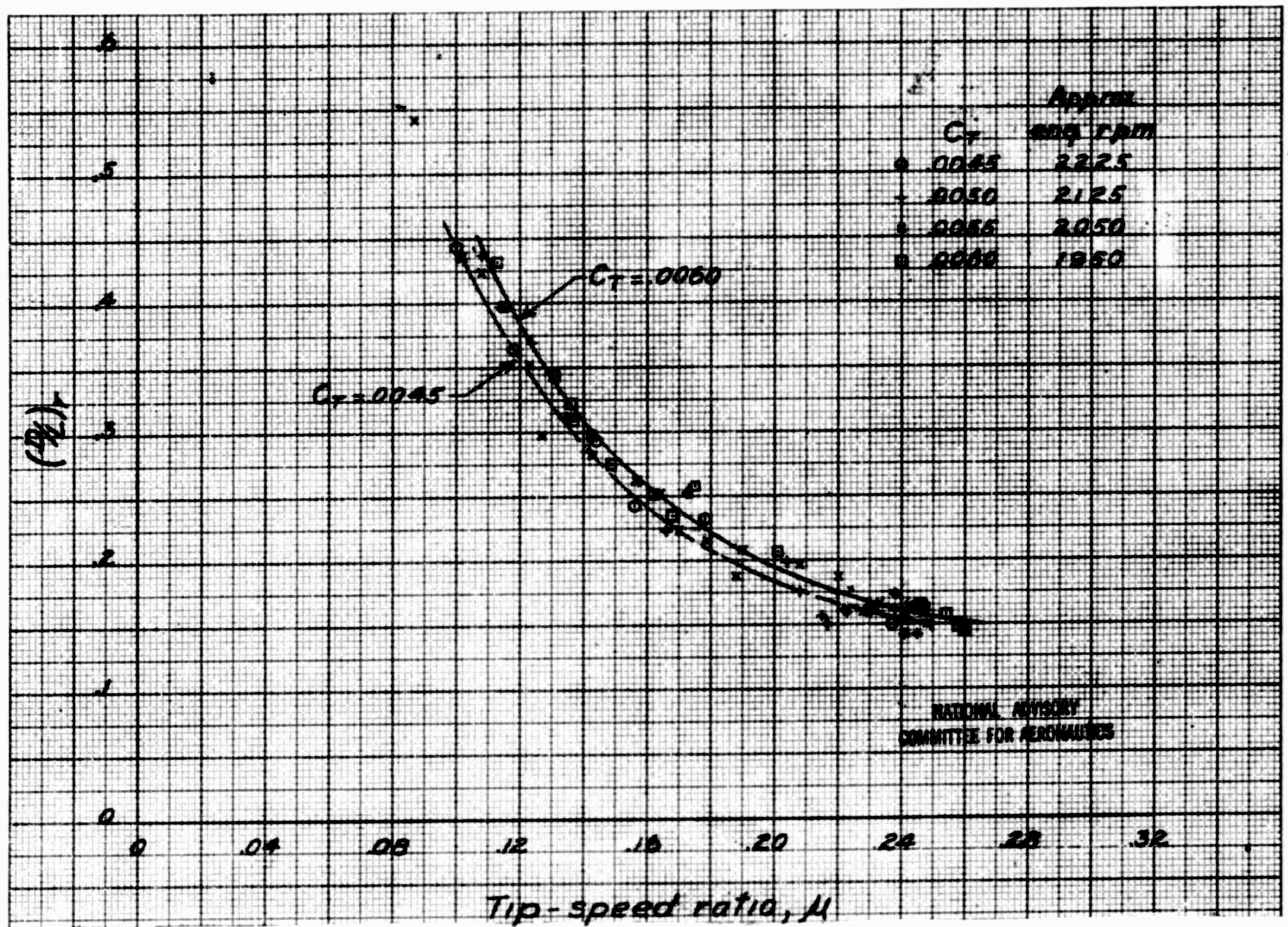

Figure 10.- Drag-lift ratio $(D/L)_r$ for the main rotor of the HNS-1 helicopter in horizontal flight. The drag of the hub structure and the cylindrical blade shanks has been charged to fuselage parasite values.

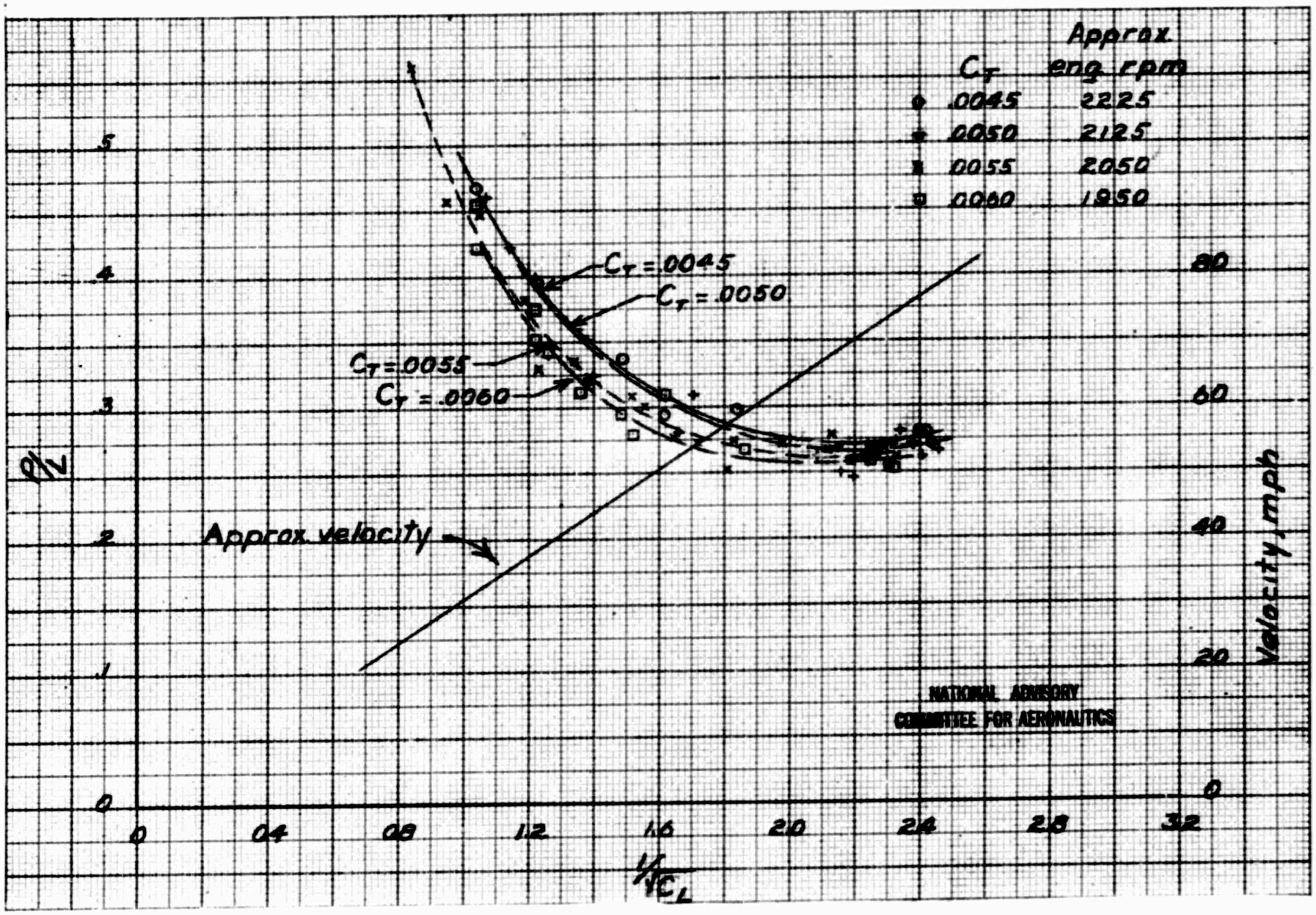

Figure 11.- Equivalent main rotor drag-lift ratio, P/L, vs. the velocity parameter $1/\sqrt{C_L}$; HNS-1 helicopter in horizontal flight.

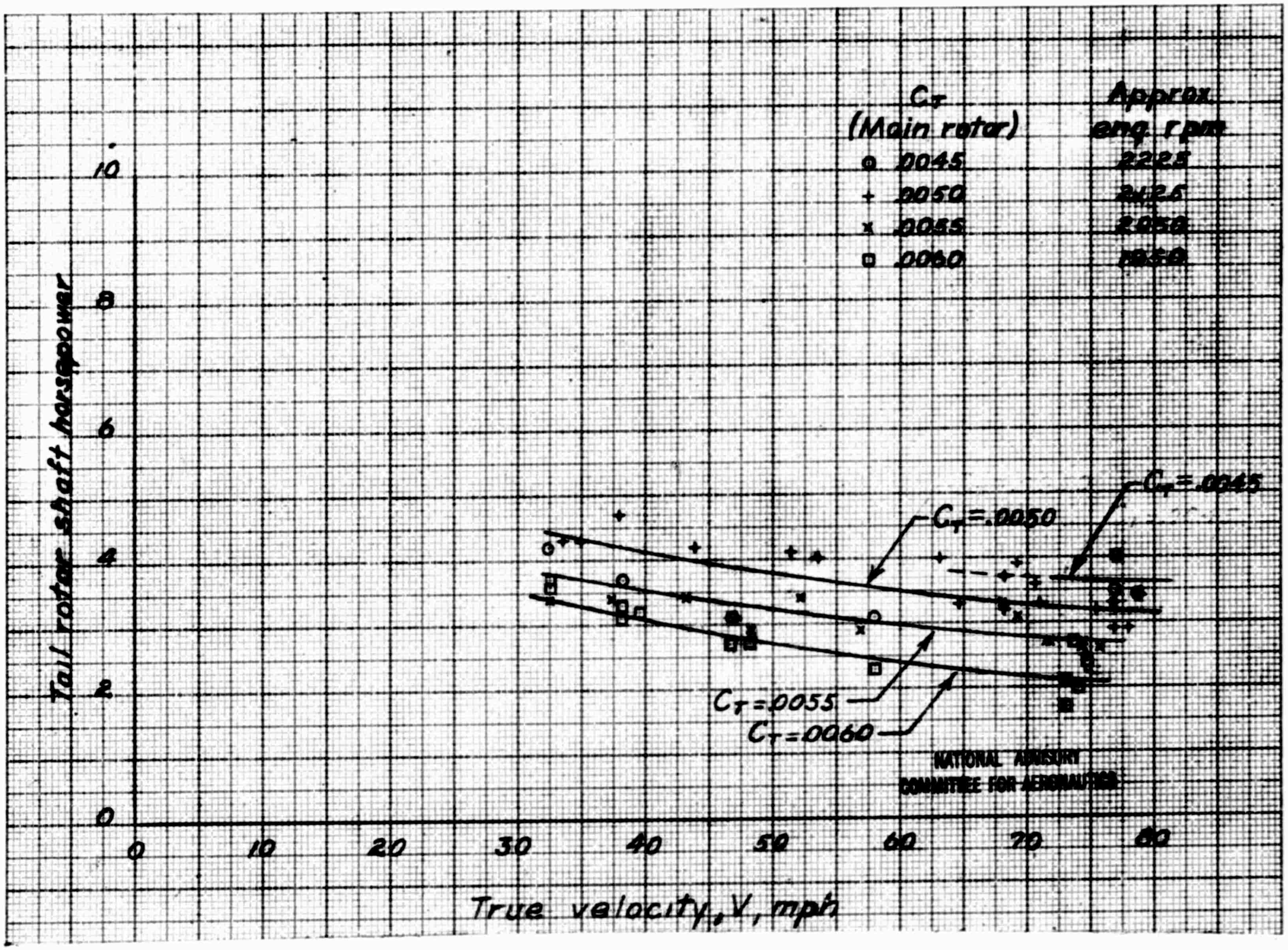

Figure 12.- Tail-rotor shaft power vs. true speed for the HNS-1 helicopter in horizontal flight.

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Flight Tests of the Sikorsky HNS-1 (Army YR-4B) Helicopter - I - Experimental Data on Level-Flight Performance with Original Rotor Blades

33410

(None)

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Langley Memorial Aeronautical Lab., Langley Field, Va.

MR-L5C10

National Advisory Committee for Aeronautics, Washington, D. C.

(Same)

March '45	Unclass.	U.S.	Eng.	34	photos, tables, diagr, graphs

Level flight performance measurements were made on the YR-4B helicopter with the original set of main-rotor blades and a gross weight of approximately 2560 pounds. The minimum shaft power required by the main rotor at cruising rpm (225 rotor rpm, 2100 engine rpm) was approximately 99 hp at a speed of 40 mph. The shaft power absorbed by the tail rotor at cruising rpm was approximately 3 to 4 hp over a range of speeds from 25 to 80 mph.

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Rotating Wing Aircraft (34)

Helicopters - Performance (49244);

YH-4B - Flight tests (99854.473)